# Determining Wind Speeds in the Venus Atmosphere

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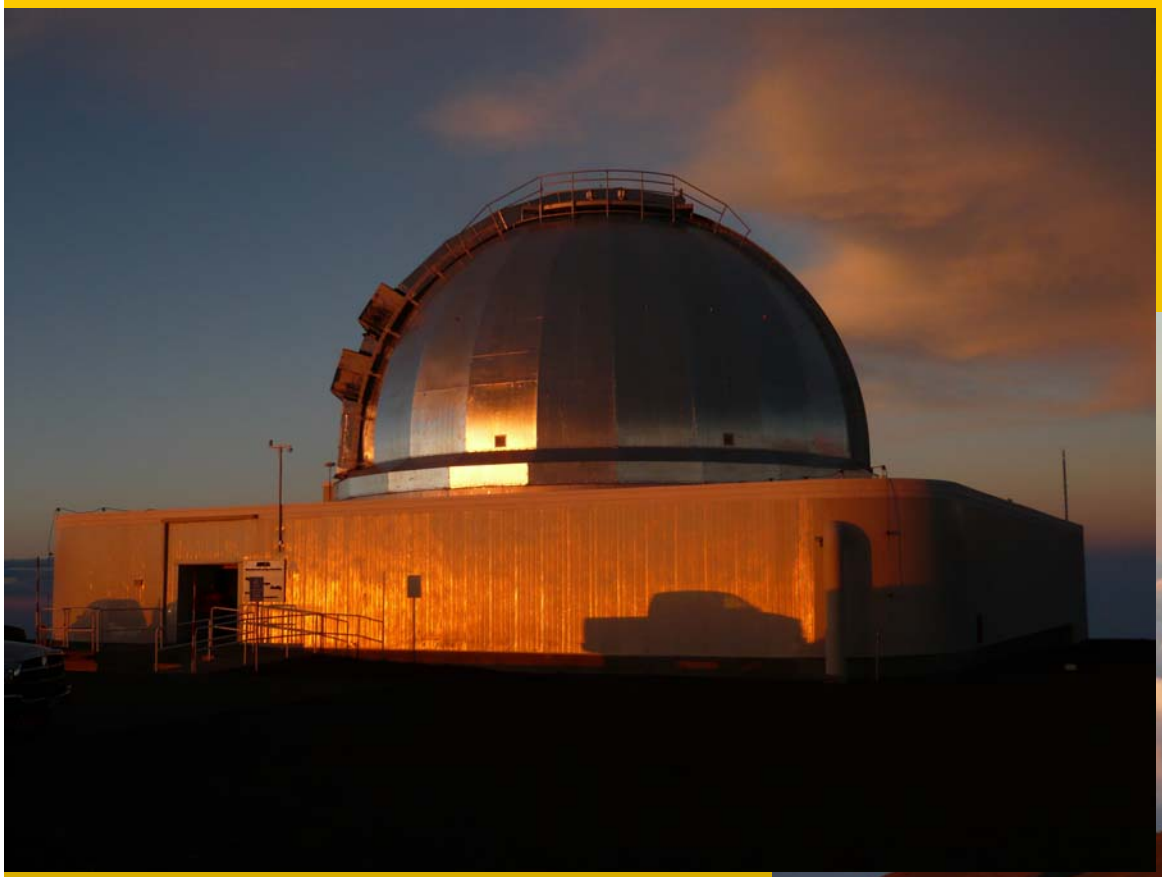
# Project Objectives

1. Sift through Venus images to identify the sharpest ones.
2. Track cloud features across the Venus disk as they move from east to west.
3. Calculate east-west wind speeds at several latitudes.
4. Try to track the much slower north-south cloud motions and calculate north-south wind speeds.

# NASA’s Infrared Telescope Facility



Mauna Kea, Hawaii

13,500 feet

# NASA's Infrared Telescope Facility

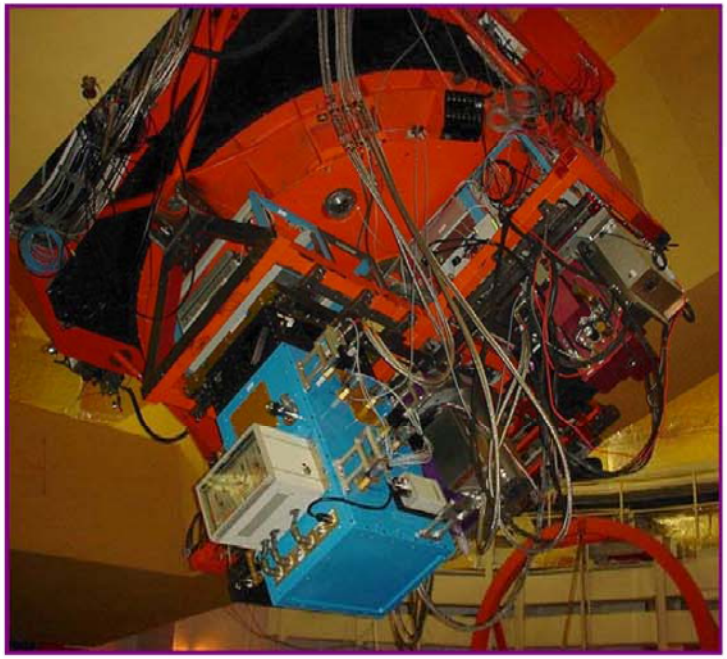
- 3 meter infrared telescope
- Imaging and Spectroscopy
- Main planetary telescope operated by NASA

# The Control Room

# The SpeX Camera/Spectrometer

# SpeX:

## 0.8-5.5 Micron Medium-Resolution Spectrograph and Imager



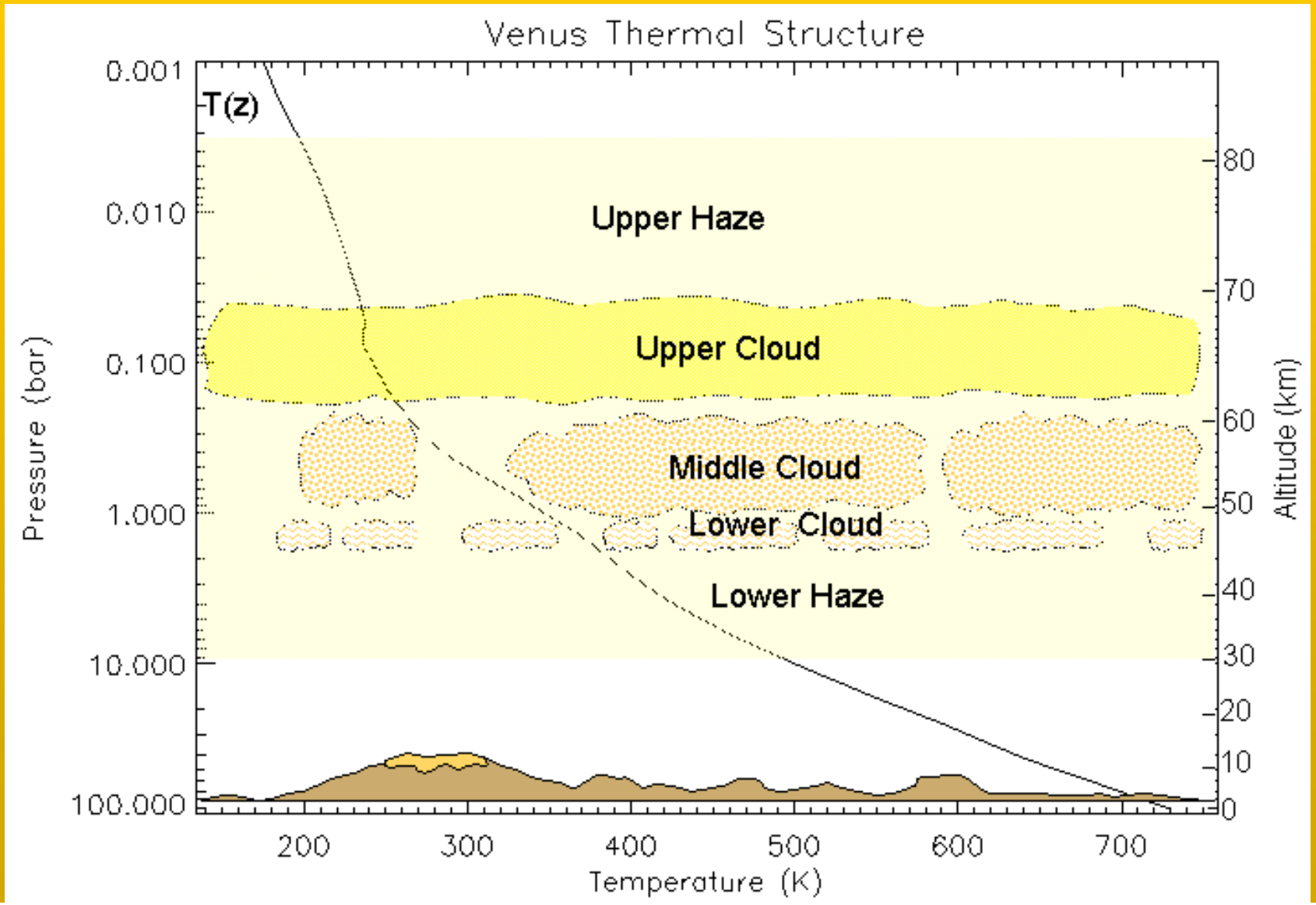
## Introduction

SpeX is a medium-resolution 0.8-5.4 micron spectrograph built at the Institute for Astronomy (IfA), for the NASA Infrared Telescope Facility (IRTF) on Mauna Kea. The primary scientific driver of SpeX was to provide maximum simultaneous wavelength coverage at a spectral resolving power which is well-matched to many planetary, stellar and galactic features, and at resolving power which adequately separates sky emission lines and disperses sky continuum. This requirement has resulted in an instrument which provides spectral resolutions of R~1000-2000 across 0.8-2.4 micron, 2.0-4.1 micron, and 2.3-5.5 micron, using prism cross-dispersers (15 arcsec-long slits). Single order long slit (60 arcsec) modes are also availavble. A high throughput prism mode is a provided for 0.8-2.5 micron spectroscopy at R~100 for solid state features and SEDs. A Raytheon Aladdin 3 1024x1024 InSb array is used in the spectrograph.

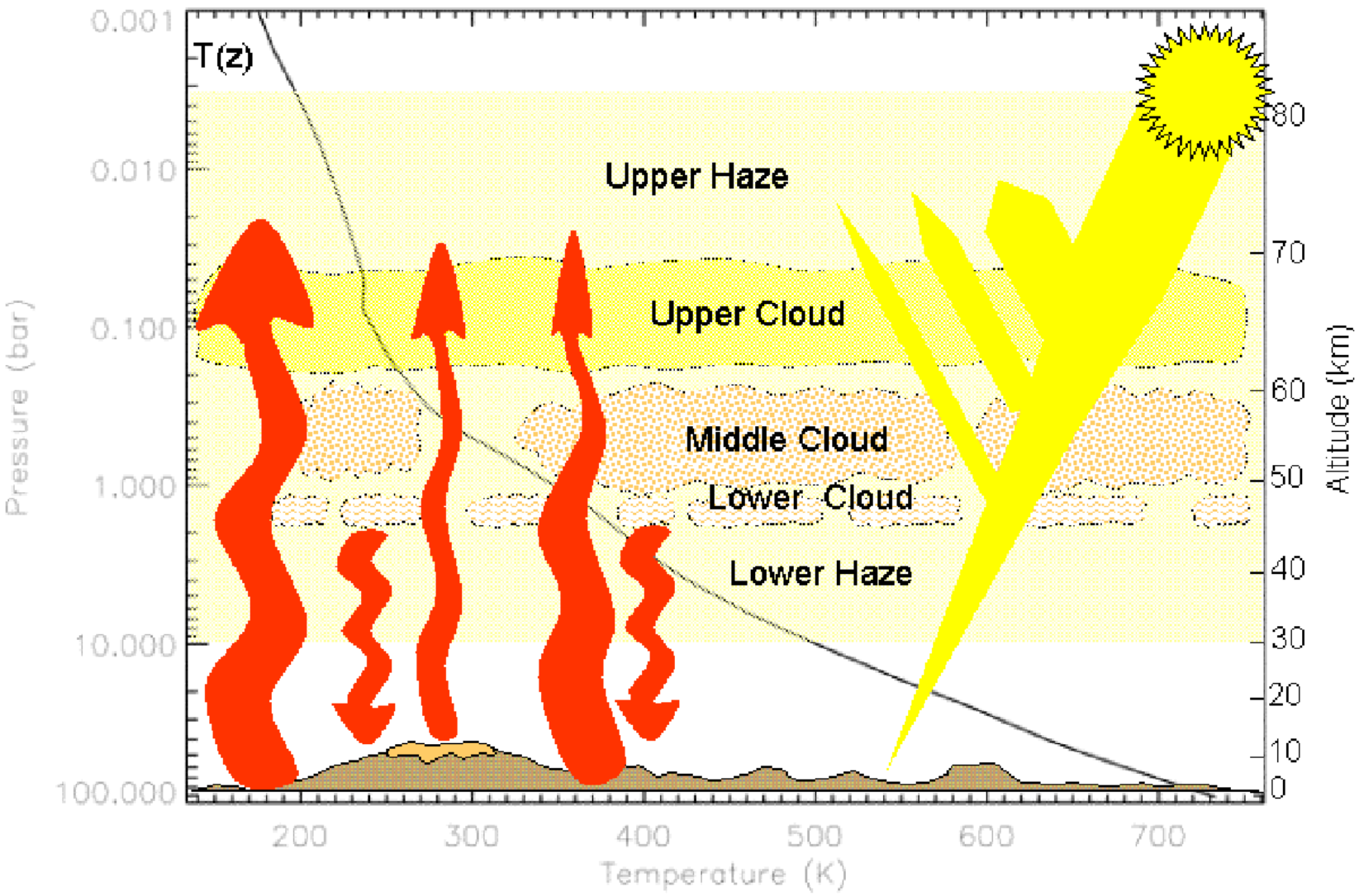
SpeX also contains an infrared slit-viwer/guider covering a 60x60arcsec field-of-view at 0.12arcsec/pixel. A Raytheon Aladdin 2 512x512 InSb array in the infrared slit-viewer.

SpeX was funded by the National Science Foundation (NSF) with additional funding from NASA for the detector arrays.

# The Venus Atmosphere

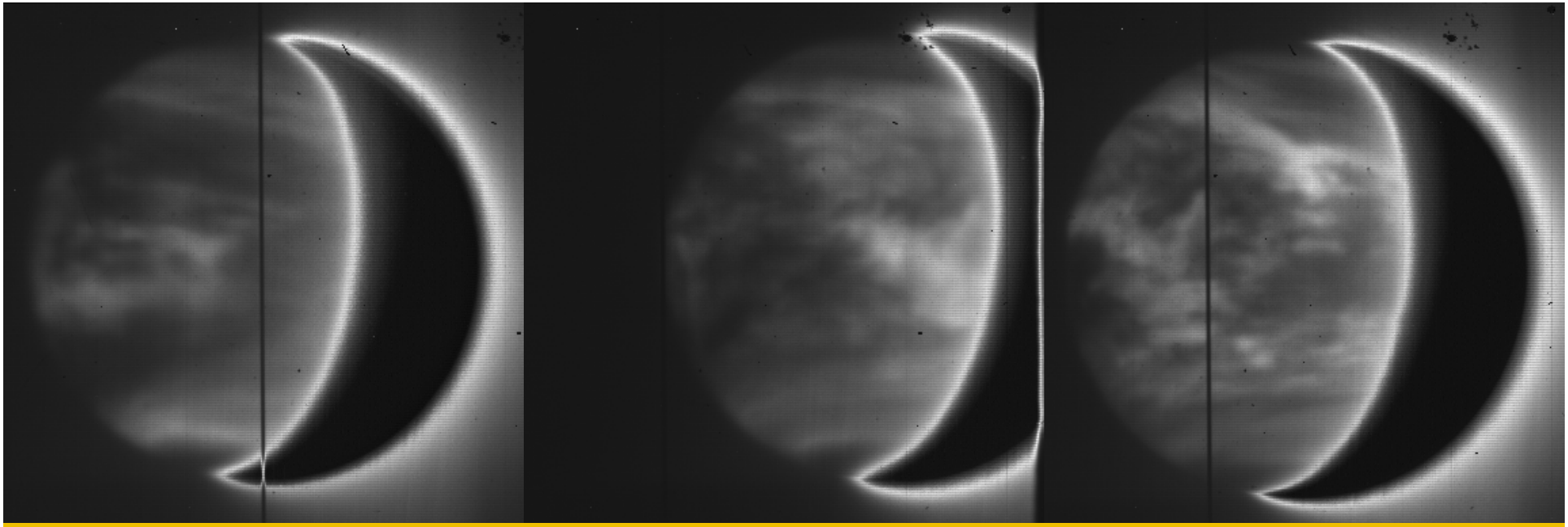


# Thermal Radiation

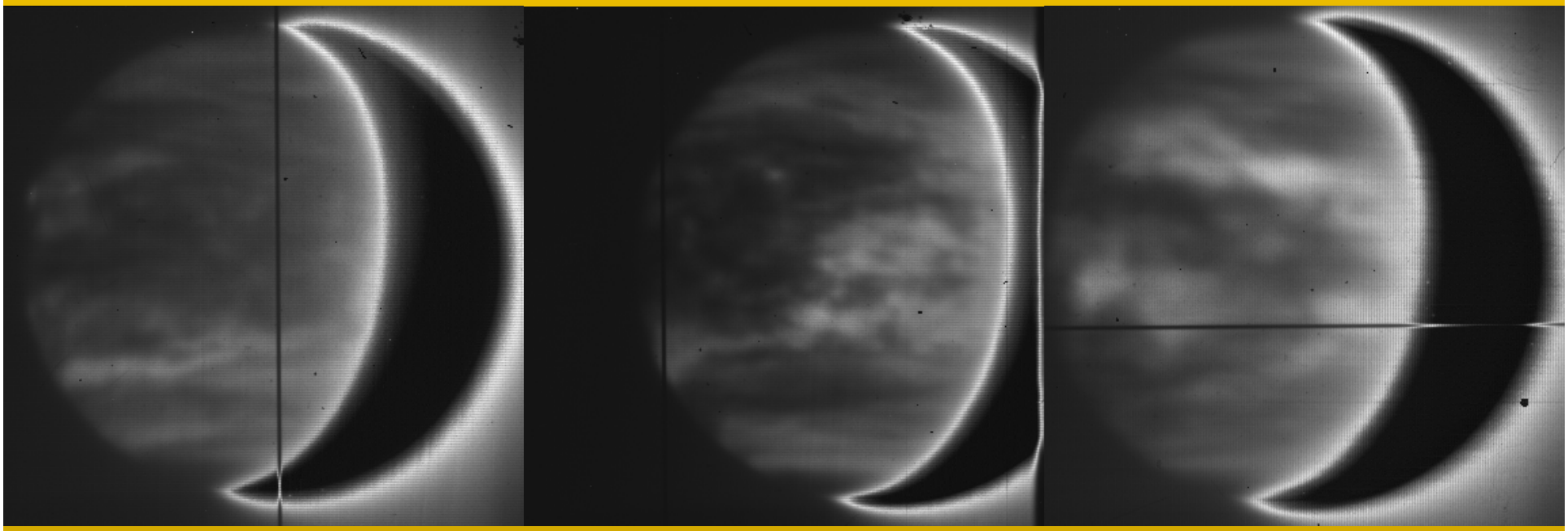


# Venus Images

- We look at the nightside of Venus.
- Main infrared ‘windows’ are at 1.7 and 2.3 microns – about 5 times longer wavelength than we can see with our eyes.
- Infrared radiation coming from the deep atmosphere silhouettes the clouds from below.
- We have images from:
  - 7 nights in May 2001
  - 7 nights in September 2002
  - 6 nights in May 2004
  - 10 nights in July 2004
  - 5 nights in February 2006
  - 11 nights in July 2007
- Somewhere in the neighborhood of 30,000 images!



May 4, 2004 Venus 2.3 μm May 5, 2004 IRTF May 6, 2004



May 8, 2004 Eliot Young May 9, 2004 Mark Bulllock May 10, 2004

# Cloud Motion - 14 Sept 2007

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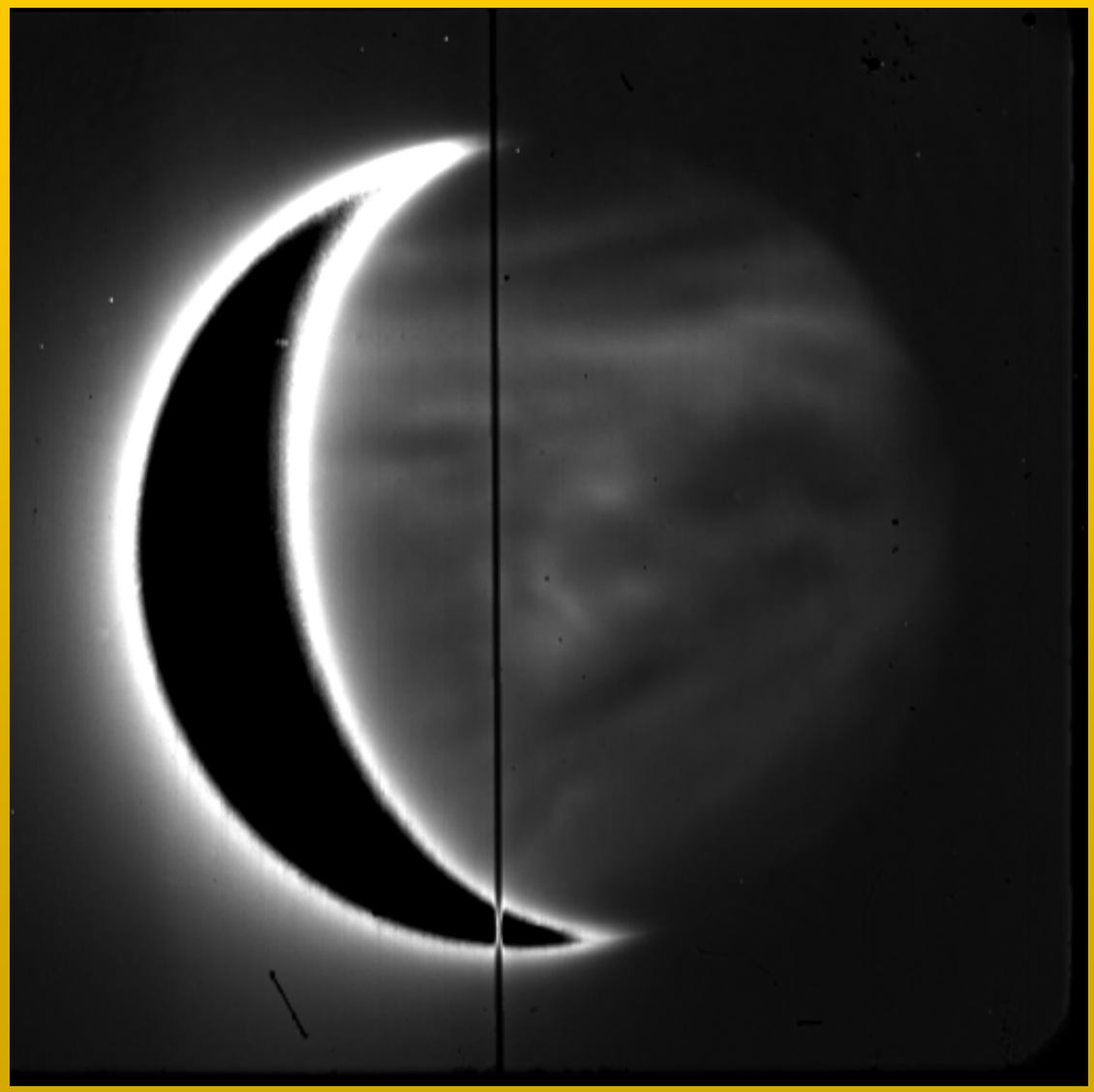
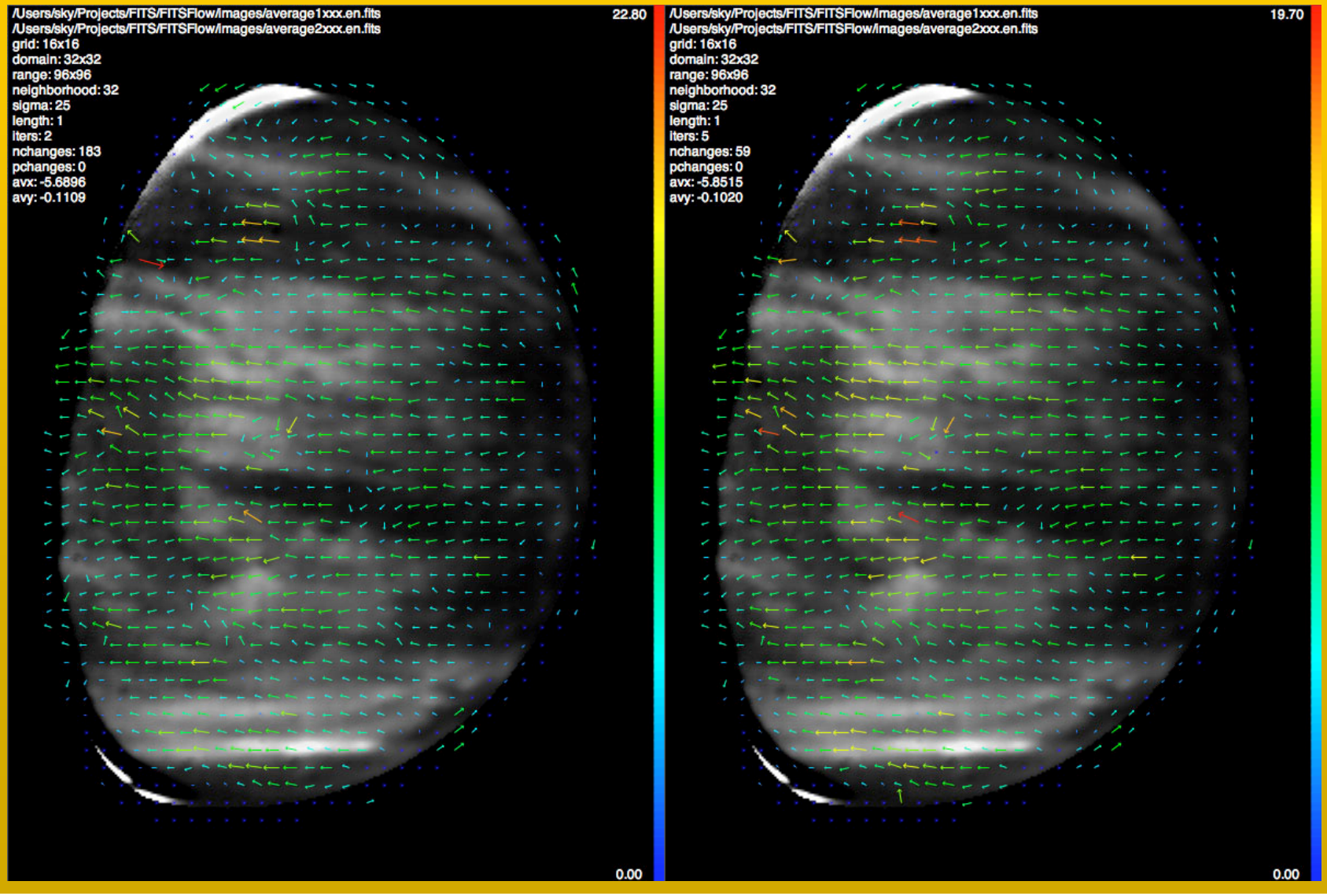
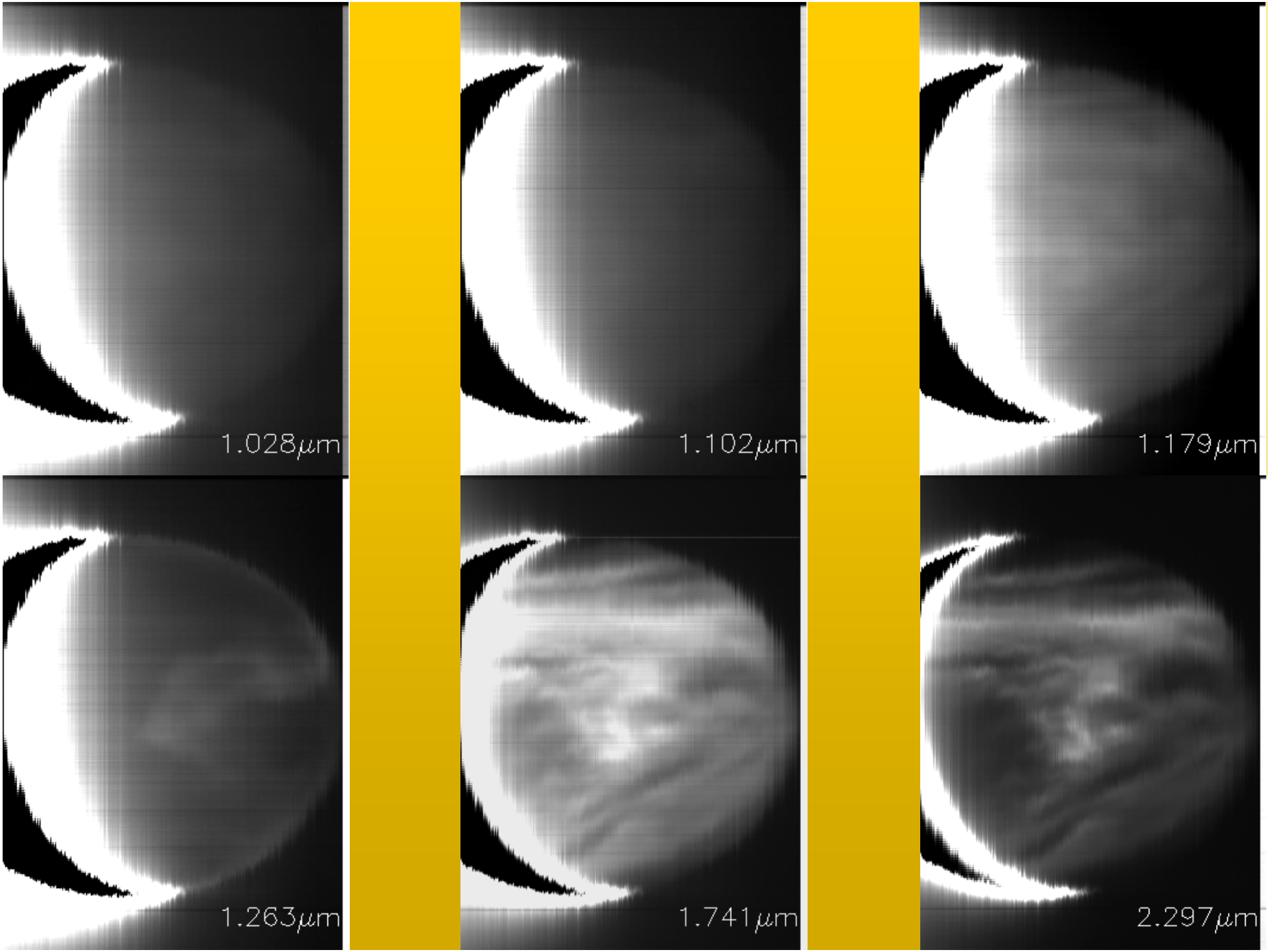
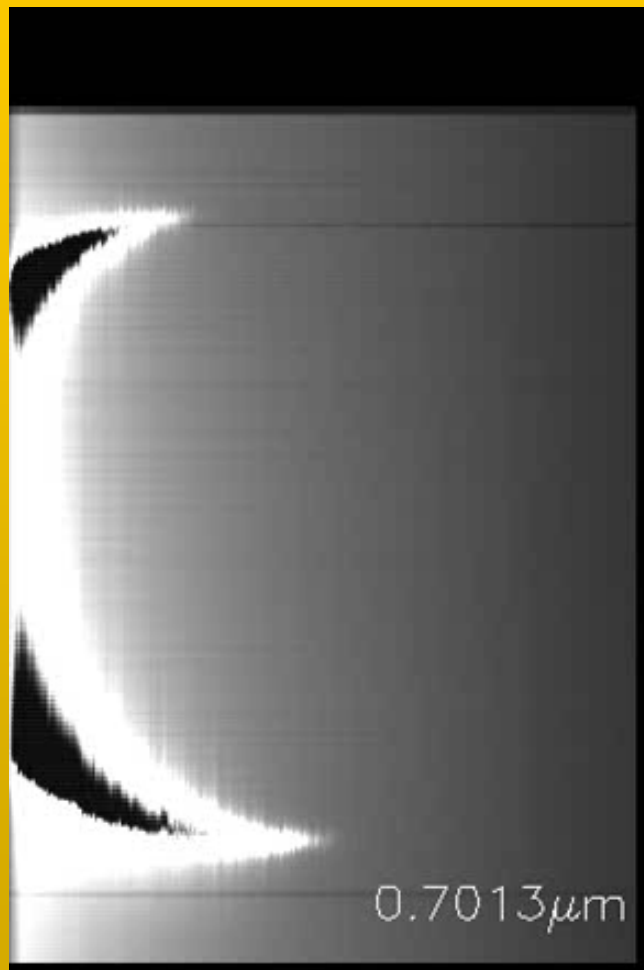


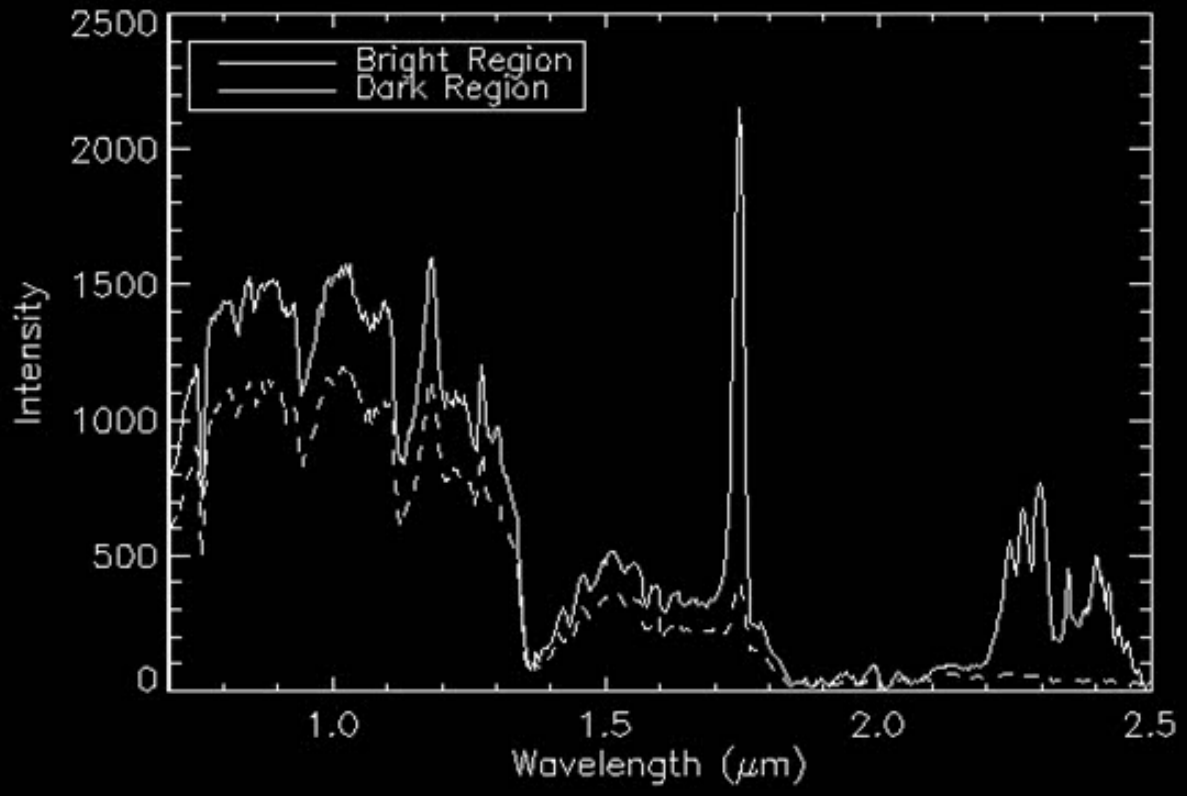
# Automated Cloud-Tracking




1.028μm
1.102μm
1.179μm
1.263μm
1.741μm
2.297μm

# Near-IR Windows on Venus Nightside



# Image Issues

- All images are in the FITS format, a standard astronomical format for images and spectra.
- FITS files contain images and header information with instrument and image data, and time information.
- FITS images and headers can be viewed with astronomical image software such as The Sky, or with a free Adobe Photoshop plug in from ESA/ESO/NASA called FITS Liberator 2
- Mixed in with the Venus images are blanks, standard stars, and images at a different wavelength that don’t contain cloud information.
- Because the disk of Venus was allowed to drift across the field of view, the images are not in the same place from one image to the next.

# Rough Procedure

1. View each image and pick the sharpest 10-20%.  Note the exact time, to the second, of each selected image.
2. Align all selected images to the same coordinates (center).
3. For each observing night, pick fiducial marks on the earliest images.
4. Track the fiducial marks for each observing night and draw arrows indicating atmospheric motion.
5. Calculate wind speeds based on scales and geometric factors that I will provide.